

INSTITUTE AND FACULTY OF ACTUARIES

EXAMINERS' REPORT

September 2011 examinations

Subject ST9 — Enterprise Risk Management Specialist Technical

Purpose of Examiners' Reports

The Examiners' Report is written by the Principal Examiner with the aim of helping candidates, both those who are sitting the examination for the first time and who are using past papers as a revision aid, and also those who have previously failed the subject. The Examiners are charged by Council with examining the published syllabus. Although Examiners have access to the Core Reading, which is designed to interpret the syllabus, the Examiners are not required to examine the content of Core Reading. Notwithstanding that, the questions set, and the following comments, will generally be based on Core Reading.

For numerical questions the Examiners' preferred approach to the solution is reproduced in this report. Other valid approaches are always given appropriate credit; where there is a commonly used alternative approach, this is also noted in the report. For essay-style questions, and particularly the open-ended questions in the later subjects, this report contains all the points for which the Examiners awarded marks. This is much more than a model solution – it would be impossible to write down all the points in the report in the time allowed for the question.

T J Birse
Chairman of the Board of Examiners

December 2011

General comments on Subject ST9

The ST9 exam generally requires bullet point form or short form essay style answers that apply general principles to directly address specific circumstances. The answers given below are just one possible set of acceptable answers. Candidates are awarded marks for all reasonable answers including different but still reasonable numerical solutions. Marks are awarded for working in the case of numerical answers.

Comments on the September 2011 paper

Well-prepared candidates scored acceptably well across the whole paper. The comments that follow the questions concentrate on areas where candidates could have improved their performance.

1 Administrative points need to be included such as:

- policy owner;
- sign off;
- date of sign off and next review; and
- applicability to business units, activities and products.
- Approved risk taxonomy

The risk policy should also include the risk appetite, risk tolerances and risk limits.

The risk policy should provide guidance on the identification, measurement, selection and management of risk.

The risk policy should cover risk governance including roles and responsibilities. In particular, the escalation processes should be outlined.

The question was handled well by most. Many candidates failed to note the administrative points.

2 (i) The director may be correct in that the bank has implemented risk management *processes*, but has not recognised that culture is an important part of the overall ERM framework.

It may be that the bank has perceived ERM implementation as a “box ticking” exercise. For example to keep credit rating agencies, regulators or other stakeholders happy.

However, if the risk management culture is not strong then the rest of the framework is unlikely to be successful, and this will not impress such observers.

It may be that it is recognised as being important, but a strong culture has been more difficult to achieve due to the bank’s fairly fragmented structure, both internationally and through the use of outsourcing arrangements.

Its rapid recent growth rate might mean that there has been temporary management distraction.

Or it might be taking time for positive actions to be implemented across all of the business.

The director’s fresh external perspective is likely to be quite helpful but may include some expectations that are unreasonable, perhaps based on his experiences with previous organisations that have a very different size or structure.

Being new he may be basing his judgement on initial impressions, which should be validated before further action.

- (ii) The overall aim should be to enable everyone throughout the bank to participate in risk management to some extent. If not already implemented, the following actions should be taken to achieve this:
- The Board should ensure that it is leading by example, prioritising risk management issues as a matter of course.
 - All line managers should have defined responsibility for managing the risks within their areas of accountability.
 - Line managers should be required to report on the more important risks to a central point.
 - The bank should communicate regularly and openly about risk management matters to all staff, e.g. via regular e-bulletins.
 - The bank's intranet could be used to highlight the importance of risk management buy-in.
 - There should be clear processes in place that enable all staff – not just managers – to be involved in the identification of new and enhanced risks.
 - Easy reporting mechanisms should be implemented for other aspects, e.g. ideas for increasing opportunities, mitigation suggestions, procedure failures.
 - The bank could offer regular prizes to staff for the best risk management related suggestions.
 - Performance management for all staff could be introduced that are clearly related to risk management objectives.
 - Performance based remuneration for all staff could be introduced that are clearly related to risk management objectives.
 - The bank should ensure that there are risk management champions throughout each part of its international operations, and that there is strong liaison between them.
 - It should also engage with its outsourcing suppliers to ensure that there is consistency in terms of risk management culture, to avoid dilution of the messages.
 - The bank should ensure that there are adequate checks and validations within the risk management framework to minimise the risk of bias.

- Train all staff in the importance/role of risk management.

(iii) **Know your business**

- The bank must not seek to impose its own framework on the insurer
- The bank must recognise the importance of understanding the different specific risks of the insurance company, particularly those that relate to activities not undertaken by the bank (e.g. insurance risks)

Set limits and boundaries

- Risk limits and metrics should be specific to each of the businesses, taking into account different products, target markets, geographical areas of operation, possibly sizes, capital structures, risk types.
- However, the bank should also aim for consistency within the combined risk management framework

Use the right yardstick

- These limits and metrics should influence the choice of performance objectives and measures set for managers and staff
- These should be consistent for similar roles across the two organisations, allowing where appropriate for specific issues

Pay for the performance that you want

- Compensation policies should be aligned to these risk measures and the objectives of the company.
- To avoid staff dissatisfaction, they should be consistent between the two organisations for roles of similar levels and responsibilities.

Establish checks and balances

- Care should be taken not to create excessive concentrations of risk – for example by it may be useful to incorporate restrictions such as additional checks and balances if the investment assets of both businesses are combined and therefore exposed to the same operational risks.
- The bank should also avoid creating increased concentration of power or authority of specific individuals as a result of the integration.

Keep your eye on the cash

- This applies equally to ensure that the management of cash flow for both entities remains appropriate to their requirements after the combination

- The bank should assess the quality of the insurer's financial authorisation and control processes, and might either adopt them itself or introduce its own internal processes, depending on their relative strengths.

Balance the yin and the yang

- Management should not overlook the “softer side” of risk management and the development of a combined culture for the firms.
- Given the earlier suggestions about the quality of risk management culture within the bank, it is possible that it can learn something from the approach taken by the insurer.

The question was handled well by most.

Part (iii) says “when integrating the risk management frameworks of the businesses.” Hence the answer should be specific to the businesses and not just a restatement of the generic description in Lam.

- 3**
- (i) The bank is exposed to the risk of the market value of the net trading book being less than expected. The three main sources of risk are:
- Movements in interest rates underlying the swaps. This is made up of the delta, gamma and vega of the interest rate curves being essentially vertical changes in the curve, changes in shape and the rate of change in the slope respectively.
 - Movements in foreign exchange rates relative to the Bank's reporting currency. This risk will be on the net trade position gross of any collateral.
 - Counterparty risk remaining after trades are netted and collateral is taken into account.
- (ii) A summary of the mark to market value of the net trades produced at different points in the past (say monthly).

The summary would be separated into interest rate swaps and foreign exchange swaps.

The interest rate swap summary would be broken down into interest rate reset term and the remaining term of the swap.

The foreign exchange swap summary would be broken down into foreign currencies being swapped and the remaining term.

The summaries are needed at different points in order to estimate the likely range of potential growth in the book over the forecast period.

Alternatively one could assume a range of hypothetical growth rates.

Daily volatility estimates for interest rates provides an estimate of delta.

It will be necessary to input estimates of gamma and vega or least the observed impact to the historical trading book of historical changes in gamma and vega.

A list of net (of both trades and collateral) counterparty exposures by counterparty and by rating.

Time horizon

Choice of probability distribution for volatilities, if assumed variable

Default probabilities by counterparty rating

- (iii) The risk model should produce a probability distribution of the future mark to market value of the net trading book.

The risk model could estimate the distribution of the net book at different points in the future and so produce a number of different distributions.

The risk model should produce a number of key statistics including expected value, modal value, 90th percentile (probability that the value of the book will not be less than X in 90% of modelled scenarios), 95th percentile and 99th percentile.

The risk model should produce relative estimates of the major sources of variability e.g. exposure to one or more particular currencies and/or counterparties.

- (iv) The model is based on volatility estimates and the linear correlation coefficient. This is reasonable if the underlying interest rate change/ exchange rate change distributions are normally distributed or at least elliptically distributed.

However, past observations of financial data suggest that the underlying distributions are not normal and are more likely to be relatively fat tailed, which would lead to underestimation of the risk to the bank.

The model is based on daily volatility estimates. Extrapolating the daily volatility estimates into weekly, monthly, annual forecasts may be expected to be increasingly inaccurate, since volatilities can change rapidly. Other things equal, the model should produce reasonable estimates for short forecast periods.

The volatility estimates are likely to be the major reason for variation around the mean when forecasting results which are not extreme e.g. say between 10th

and 90th percentile. Other things equal the model should produce reasonable results for the bulk of the distribution but possibly not the tail.

Past observation of financial data also suggests that the correlations between financial instruments can increase greatly in times of stress and under relatively extreme events, which will again underestimate the risk to the bank in these conditions.

The question was in the main not well answered by many. Questions (ii) and (iv) were found to be particularly difficult.

For part (iv) some candidates gave the alternative and more generic answer about model specification, parameter error etc. Marks were given for this answer if the points were valid and if they addressed the specific circumstances.

- 4**
- (i) Snooze Air plc has purchased futures contracts so as to lock into the aviation fuel prices that are currently priced into the futures contracts. In particular, it is protecting itself against increases in the price of aviation fuel above this level over the next 18 months. Assuming the company's forecasted usage of aviation fuel is accurate, the use of futures contracts may help the company to manage its earnings volatility.
 - (ii) A worsening economic environment would likely lead to lower passenger volumes and possibly reduced schedules. Where this is the case the company will have purchased futures contracts for fuel that is no longer needed leading to a mismatch.

On the other hand, the company may have under-estimated its fuel consumption needs (e.g. by over-estimating the fall in demand), and would remain exposed to fuel prices in relation to this shortfall.

A worsening economic environment would also likely lead to lower fuel prices resulting in losses on the purchased futures contracts, including those futures contracts relating to any mismatch.

The protection afforded is only available in the short term. Once the futures contracts mature, the company will once again be exposed to fluctuations in the price of aviation fuel, which may mean paying far higher prices than those that are priced into the futures contracts.

The futures contracts are listed on the New York Mercantile Exchange with likely delivery in the American Northeast. Therefore, the company is exposed to local factors that lead to differences in the price of aviation fuel in the America Northeast and the UK.

This approach may need cash to pre-fund some of the future fuel costs because if the future contracts go out of the money then Snooze Air will have to meet margin payments.

Snooze Air may not have the requisite expertise to buy and administer the contracts.

It is possible that the currency for the contracts is different from the currency in which Snooze Air usually buys its fuel. This gives rise to different if not additional currency risk which will need managing.

The question was handled well by most.

- 5** (i) T is the term to maturity of the debt. This is the logical point in time to test whether the value of the firm is more than or less than the debt repayment.

The probability of default increases as the ratio of B/V_0 (the value of the debt to the original value of the firm) increases. This makes sense as the firm is more leveraged and closer to $V_t \leq B_t$.

The higher the mean value of the firm μ_V , the lower the probability of default makes sense, particularly if μ_V is large relative to the volatility in the firm value σ_V .

As volatility in the firm value σ_V increases the probability of default should increase, since there is more chance for V_t to slip below B_t in any given scenario.

The denominator being $\sigma_V \sqrt{T} : \sqrt{T}$ is the standard way to adjust volatility for time.

Marks were also given for showing how the formula fits the Black Scholes formula as it's a call option.

- (ii) It is only a one period, single firm model and so not useful for portfolio management purposes.

Key factors in the model are B , V_0 , μ_V , σ_V and T . \tilde{d}_j are asset value levels that mark the boundaries of higher rating categories.

The firm's management would gain insight into its business once it saw that σ_V and \tilde{d}_j are not within their direct control. T is simply the time horizon.

V_0 and μ_V are potentially changeable by management if it were to raise new equity or distribute some back. The level of debt B is probably the easiest and most direct thing for management to control.

The firm's management could use the model to judge the extent to which they would need to change their debt and equity structure to change their rating.

Alternatively the firm's management could estimate the probability of a rating change (including default) over the single period of time T .

External credit analysts could use the model to estimate the immediate impact on the firm's debt rating of significant changes in the firm's outstanding debt and/or share price. This can help the analysts' clients to decide on potential trades. Actual changes in credit ratings can take some weeks.

Alternatively external credit analysts could estimate the probability of a rating change (including default) over the single period of time T . They could then advise their clients of the relative proximity of the firm's debt to upgrade or downgrade and the probability of default over time horizon T .

Marks were given for alternate answers such as it might trigger a full rating review by the external analyst or that the model could be used to help gauge reactions to market movements.

- 6** (i) 100% positively correlated risks will have no diversification benefits. Conversely 100% negatively correlated risks will effectively cancel each other out

In relation to economic capital calculations, diversification benefits arise where the risks being assessed are less than fully correlated.

The probability that such risks will crystallise at the same time is likely to be less than the confidence level at which the economic capital is determined.

Consequently the amount of overall capital that needs to be held for the combined risk events is less than the sum of the capital amounts that would need to be held for each risk separately.

The diversification credit will increase as the correlation changes from 100% positively correlated to 100% negatively correlated. The increase in the diversification credit is not linear as the correlation coefficient decreases between 1 and minus 1.

- (ii) Undiversified = $5.5 + 2.25 = 7.75$

$$\text{Diversified} = \text{square root } \{5.5^2 + 2.25^2 + 2 \times 0.25 \times 2.25 \times 5.5\} = 6.44$$

$$\text{Diversification benefit} = 7.75 - 6.44 = 1.31$$

Several candidates misread the correlation matrix.

- (iii) Calculate the economic capital using a single mortality deterioration or longevity improvement stress test covering both products at the same time. In this way the loss on one block is automatically offset against the gain on the other in the components of the calculation. However, the 100% correlation assumption would need to be interrogated.

Marks were also given answers involving a simulation model with joint probability distributions etc.

- (iv) The new contract is primarily exposed to market risk. This will introduce potential diversification benefits but will also introduce new risks to the company.

This will provide a new dimension to the risk profile that will allow for more diversification benefit.

Will need to consider the levels of correlation between the new and existing products.

The correlation will not be zero, i.e. not completely independent, but it is likely to be relatively small given the different nature of the main underlying risks.

It should also be noted that volumes of business written may have to be significant before the increased diversification benefit is tangible. It may take time therefore before there is any impact on capital requirements.

The new contract requires different core competencies and expertise to the existing business. These may not be available in the business. This therefore increases the operational risk exposure of the business while the expertise builds up.

If additional operational risk capital is required it will (partially) offset any benefit of the increased diversification credit.

An additional mark was awarded for candidates who noted that product changes could help to reduce the risk e.g. removing the minimum investment return guarantee.

7 Risk Tolerance Statement

A company's risk tolerance statement is a relatively detailed set of statements, many of which will be quantitative or statistical in nature. The statements will likely include targets and limits to specific categories of risk and/or units of business.

Risk tolerance often includes the Board's appetite for reductions in its profit and/or the ability to pay dividends. This concept incorporates the idea of wishing to increase or at least maintain profitability but recognising that there are risks and sometimes profit will be lower than desired.

Importantly the profit objective may not be an equal priority for all stakeholders. The risk tolerance statement will include other metrics which together should comprise a more balanced set of objectives to meet the group of stakeholders.

Operating at the Limit of the Stated Risk Tolerance

In order for a company to operate at the limit of its stated risk tolerance it will need to:

- Implement and embrace ERM at a level of sophistication which is at least equal to the detail contained in the risk tolerance statement.
- Regularly publish the risk tolerance statement. It will incentivise both the board and management to make the risk tolerance statement clear, comprehensive and up to date.
- Regularly publish information describing whether the company believes it is operating at/below/above its stated risk tolerance. This level of information will be very useful to stakeholders wishing to analyse the company.
- Have the capital in order to have the capacity to operate at its chosen risk appetite threshold.

Targeting Profit

Most companies are required to report annually or more frequently. This time horizon may be too short for measuring profit.

Profit is measured. It is the result of a large number of processes, many of which may be outside of the control of the management. Hence targeting profit is targeting something that is at least in part fortuitous.

This said, because profit is both a measured outcome and a very important key performance indicator for the company, it is often used for staff performance appraisal and bonuses. In other words, management may still be focusing on profit even when the Board's stated primary objective is to operate at the limit of its stated risk tolerance.

Targeting profit may make management more inclined to act contrary to the other stakeholders' wishes, for example, taking unnecessary risk or taking short term measures which may increase short term profits but are likely to reduce aggregate profits over the long term.

Targeting Risk Measures

Risk is estimated. It can be continually monitored. In this sense it is not subject to either the time horizon issue or to fortuitous results. Fortuitous results are just the consequence of different actual observations across the risk spectrum.

Profit is likely to be much more volatile than risk tolerance.

By setting the objective to operate at the limit of the risk tolerance the company is implying that expected profit will be maximised providing that the company is able to operate on the efficiency frontier. This is useful as it allows the stakeholders to focus on monitoring things which are within the control of the management, namely, the risk it is taking and the efficiency with which it is managing the business. Targeting risk tolerance is more useful for the board and the corporate governance policy as it represents control and management and not just outcome.

Stakeholders

Investors can diversify risk. Modern portfolio theory suggests that investors demand additional expected profit for taking additional risk. All too often it is not possible for investors to assess the risk a company is taking to achieve its returns. It will therefore be very useful to investors to have companies publish and monitor their adherence to stated risk tolerance and to make their objective to operate continually at the stated level. Traditional risk measures based on share price volatility and or profit volatility are very poor measures of the underlying risk that a company believes it is taking.

Bondholders, credit rating agencies and regulators will all be much more concerned with risk and the comparable capital of the company than a profit objective.

Many stakeholders will be concerned to try to estimate the extent to which two or more company's share price are correlated. More particularly they will likely be concerned to try to estimate correlation in extreme events. Providing the companies have similar or at least stable primary objectives then the correlation estimations can be reasonably derived from the historic share price movements. However, for the purpose of estimating correlation under extreme events the detail in the risk tolerance statements and the resulting history of profits should prove to be a very useful differentiator. (need to explain).

Suitability to All Companies

Targeting the limit of the risk tolerance statement is likely to be suitable for the majority of medium sized and larger companies. It may not be appropriate for small companies, sole traders, privately held companies, publically owned companies. Companies with relatively few stakeholders and /or particularly well informed stakeholders may believe that the risk position is relatively stable from year to year in any case and that the profit objective is both more tangible, more focused and more appropriate. Alternatively the company may have been formed with a particular alternative set of objectives in mind e.g. a charity.

This question was not well answered by many candidates. Marks were given for a range of different approaches. Several candidates failed to address the standard investment tenet that additional expected return is generally associated with taking more risk. Hence, other things held equal, maximising profit could easily involve taking more risk than is stated in the company's risk appetite statement.

8 (i) $\text{VaR}_\alpha = \inf\{y \in \Re : F(y) \geq \alpha\}$

$$\text{TVaR}_\alpha = 1 / (1 - \alpha) \int_\alpha^1 \text{VaR}_p(L) dp$$

where:

α is the confidence level

$F(\cdot)$ is the cumulative distribution function of loss L

L is a random variable representing the loss on a portfolio of assets and liabilities

$\text{TVAR}(\alpha) = E[L | L > \text{Var}(\alpha)]$ is an acceptable alternative answer.

(ii) **Translation invariance**

The Risk Measure should show that the amount of capital required supports the perceived variability of a loss and not its expected amount. Adding or subtracting a fixed amount from a loss leaves the capital (being the amount excess of the expected loss) unchanged.

Subadditivity

Compounding loss distributions should create a diversification benefit. Even if the distributions were 100% correlated the Risk Measure of the compounded distribution should not exceed the sum of the Risk Measures of the individual distributions.

Positive homogeneity

Also known as positive scalability the Risk Measure should show that the capital required to support “ n ” identical losses is equal to “ n ” times the capital need to support one loss.

Monotonicity

The Risk Measure should show that the capital needed to support a smaller loss (with the same distribution) is less than the capital needed to support a larger loss.

Marks were given for correct formulas instead of descriptions.

(iii) VaR calculations

For investment strategy A we have:

$$\text{VaR}_{97.5A} = -20 \times 5,000 + 0 \times 100,000 = -100,000$$

(since zero defaults represents the 97.5th percentile for this strategy).

For investment strategy B we have:

$$\text{VaR}_{97.5B} = -18 \times 5,000 + 2 \times 100,000 = 110,000$$

(since $P(\text{Bin}(20, 2\%) \leq 1) = 0.9401$ and $P(\text{Bin}(20, 2\%) \leq 2) = 0.9929$ so that two defaults represents the 97.5th percentile for this strategy).

Marks were given for an interpolation approach.

TVaR calculations

For investment strategy A we have:

$$\text{TVaR}_{97.5A} = (-20 \times 0.5\% \times 5,000 + 20 \times 2\% \times 100,000) / 2.5\% = 1,580,000.$$

For investment strategy B we have:

$$\begin{aligned} \text{TVaR}_{97.5B} &= ((99.29\% - 97.5\%) \times (-18 \times 5,000 + 2 \times 100,000) \\ &+ (99.94\% - 99.29\%) \times (-17 \times 5,000 + 3 \times 100,000) \\ &+ (100.00\% - 99.94\%) \times (-16 \times 5,000 + 4 \times 100,000)) / 2.5\% = 142,000 \end{aligned}$$

(ignoring the probability of five or more corporate bonds defaulting since this is less than 0.01% according to the probabilities extracted from the Binomial distribution schedule).

- (iv) The VaR approach provides a simple method of setting the society's risk capital. The VaR approach is also widely used to set risk capital under regulatory regimes – e.g. Basel II and Solvency II – and by rating agencies – e.g. Standard & Poor's and Moody's.

However, the VaR approach does not give any indication of the extent to which losses might potentially exceed the 97.5% quantile. The TVaR approach addresses this issue since it is defined as the expected loss given that the loss exceeds the VaR at the same confidence level.

In addition, the VaR approach has poor aggregation properties. Specifically it fails the important subadditive property of a coherent risk measure. This means that the VaR for aggregate losses will not necessarily be less than the sum of the VaR for the individual loss distributions. This can be seen by comparing $\text{VaR}_{97.5A}$ and $\text{VaR}_{97.5B}$ for investment strategy A and investment strategy B respectively. The TVaR satisfies all the properties of a coherent

risk measure including the subadditive property. This can be seen by comparing $\text{TVaR}_{97.5}A$ and $\text{TVaR}_{97.5}B$ for investment strategy A and investment strategy B respectively.

Because the VaR approach provides a point estimate, at the extreme ends of the distribution it will often be necessary to run many simulations before the VaR estimate becomes statistically credible. The binomial approach used above is overly simplistic and would not be used in practice.

Marks were given for other valid answers.

- (v) Investment strategy B should be recommended to the Board.

The $\text{VaR}_{97.5}A$ is less than $\text{VaR}_{97.5}B$. Therefore, using a VaR approach to setting risk capital would indicate that investment strategy A, which is the less diversified of the two portfolios, would be the best option. However, we arrive at this unintuitive result because the VaR approach fails the subadditive property of a coherent risk measure.

The $\text{TVaR}_{97.5}A$ is more than $\text{TVaR}_{97.5}B$. Therefore, using a TVaR approach to setting risk capital would indicate that investment strategy B, which is the more diversified of the two portfolios, would be the best option. This is the more intuitive result that should therefore be recommended to the board.

END OF EXAMINERS' REPORT